Household Adoption of Water-Efficient Equipment : The Role of Socio-economic Factors, Environmental Attitudes and Policy

Katrin Millock, Céline Nauges

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Katrin Millock
Paris School of Economics
CNRS, Centre d'Economie de la Sorbonne
millock@univ-paris1.fr

Céline Nauges
Toulouse School of Economics (LERNA-INRA)
cnauges@toulouse.inra.fr

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Abstract

Using survey data of around 10,000 households from 10 OECD countries, we identify the driving factors of household adoption of water-efficient equipment by estimating Probit models of a household's probability to invest in such equipment. The results indicate that environmental attitudes and ownership status are strong predictors of adoption of water-efficient equipment. In terms of policy, we find that households that were both metered and charged for their water individually had a much higher probability to invest in water-efficient equipment compared to households that paid a flat fee.

Keywords: attitudes; metering; residential water use; technology adoption

Résumé

Sur la base d'une enquête sur 10,000 ménages de 10 pays de l'OCDE nous analysons les facteurs qui incitent les ménages à investir dans des équipements plus économes en eau (tels que les machines à laver à basse consommation ou les robinets à débit limité) afin de favoriser la gestion durable de cette ressource. Les résultats de l'analyse économétrique sur les réponses à l'enquête confirment que l'adoption des équipements économes en eau dépend des facteurs socio-économiques, et surtout du statut du ménage en tant que propriétaire ou non de son domicile. Par contre, le niveau de revenu n'a guère d'effet ; il s'avère que les attitudes déclarées des ménages vis-à-vis de l'environnement sont plus importantes. En termes de politiques de l'environnement nous constatons que l'adoption des équipements plus économes en eau serait fortement favorisée par l'introduction d'une tarification selon le volume d'eau utilisée ; le fait de mesurer la consommation individuelle du ménage incite fortement à installer des équipements économes en eau.

Mots clés : attitudes; mesure; consommation de l'eau; adoption de technologies

JEL codes: D12; O33; Q25; Q58

1. Introduction

Water scarcity is a global environmental problem. Even countries with abundant water supply face constraints in providing clean drinking water because of water contamination from pollution that raises the costs of water treatment. Although industry and agriculture represent the bulk of water demand, the percentage of domestic use in overall water consumption ranges from 10-30% in developed countries. Given the high costs of developing new water supply projects, we observe an increased reliance on demand side management policies, i.e., price and non-price policies designed to promote water conservation in the residential sector.

Pricing policies have received much attention by economists who consider the price to be the best instrument to induce water conservation because the welfare loss of water restrictions usually exceeds that of a price increase (Roibás, García-Valiñas and Wall, 2007; Grafton and Ward, 2008). However, because residential water demand is known to be price inelastic, managers of water utilities have often preferred to impose restrictions on water use instead of imposing higher prices. They argue that water restrictions would place a lighter burden on poorer households and would guarantee an immediate response in the case of severe and unexpected water shortages. Another type of non-price policy, that has been given little attention by economists (mainly because of lack of appropriate data), is to promote installation of water-efficient devices in residential housing. There is little data on adoption of water-efficient equipment, and with the exception of Renwick and Archibald (1998) we are not aware of any previous study that has studied adoption on a household level. The purpose of this article is to fill this gap by studying the adoption of water-efficient devices using unique survey data from around 10,000 households in 10 OECD countries.

Several countries or regions have promoted rebate programs for the installation of water-efficient technologies, among them California and Australia. Severe droughts between 1985 and 1992 in California called for continued conservation and various measures were undertaken by local water agencies including low-flow toilet rebate programs and distribution of free plumbing retrofit kits.[1] Several state governments in Australia (including Northern Territory, South Australia, Victoria) currently offer rebates for a series of labelled water-efficient products, including rainwater tanks, dual flush toilets, and water efficient shower

[1] In 2007, California became the first US state to mandate the installation of high efficiency toilets (dual or single flush), a requirement that has been phased in beginning of January 2010.

heads. The rebates vary from Australian dollar (AUD) 10-20 for a water-efficient shower head to AUD1,000 for a rainwater tank connected to toilet and laundry (for further details, see http://www.smartwatermark.org/home/rebates.asp). Installation of water-efficient devices is seen as an effective manner of inducing water conservation for several reasons. First, water consumed through both indoor and outdoor appliances (e.g., showers, toilets, washing machine, sprinklers) represents a significant share of households' daily water use in developed countries. In France, for example, it has been estimated recently that on average, more than two thirds of the water consumed daily is used for hygienic purposes (39%), toilets (20%) and cleaning dishes (10%) (source: http://www.cieau.com). A survey made in Edmonton (Canada) produced comparable figures: toilets (29%), showers/baths (34%), laundry (19%), kitchen (13%), and outdoor (5%) (source: http://www.epcor.ca). In Australia in 2001, the pattern of consumption was slightly different because of a greater amount of water used for outdoor purposes. Residential water use was split as follows: kitchen (8%), laundry (13%), toilets (15%), bathroom (20%) and outdoors (44%) (source: Water Services Association of Australia, at http://www.wsaa.asn.au). Second, the reduction potential of water saving fixtures is now well acknowledged: among other examples, a water-efficient washing machine may use only one-third the water of an inefficient model, an old-style single-flush toilet could use up to 12 litres of water per flush, while a standard dual flush toilet uses just a quarter of this on a half-flush, and a standard shower head may use up to 25 litres of water per minute whereas a water-efficient shower head might use as little as seven litres per minute (source: http://www.waterrating.gov.au.). Third, policies to promote installation of water-efficient devices are likely to be more politically acceptable than price increases or policies imposing water restrictions. Finally, another reason why adoption of water efficient equipment is a potentially interesting policy tool is the pervasive role of habits in human behaviour which may make other forms of non-price policies, such as public information campaigns, yield little effect (Thøgersen and Ölander, 2002).

In this article, we study the factors driving adoption of four types of water-efficient devices: (1) water-efficient washing machines, (2) low volume or dual flush toilets, (3) water flow restrictor taps or low flow shower heads, and (4) water tanks to collect rainwater. The dataset that we use has several interesting features: its scope (10 countries including water-abundant countries such as Canada and Norway and water-scarce countries such as Australia and Mexico) guarantees a high heterogeneity in socioeconomic and demographic characteristics of the households surveyed but also in their relationship to water in general. This large coverage also provides a large variation in terms of pricing schemes and we will be able to assess the effect of water charges and water metering on households' use of water-efficient devices, something that was not doable in studies focusing on a unique region or country. Finally, the dataset contains attitudinal and behavioural variables that measure respondents' opinions about the environment in general and their behaviour in relation to environmental preservation. van den Bergh (2008), in a survey of residential water and energy use as well as generation of waste and recycling, notes that very little attention has been paid to the influence of attitudes, perceptions and values on household environmental behaviour. Another contribution of this paper is to fill this gap by measuring the effect of attitudinal and behavioural variables on the probability of households to adopt water-efficient devices. The findings of this study should be informative for water authorities and policy makers that wish to induce adoption of water-efficient equipment.

In Section 2, we present the survey and data. In Section 3, we describe the modelling framework and we discuss the factors to take into account in the econometric models of adoption of water-efficient devices. Section 4 presents summary statistics and estimation results. Section 5 concludes.

2. The survey

The data come from the 2008 OECD Survey on Household Environmental Behaviour that aimed at collecting new empirical evidence on attitudes, behaviour and environment in five areas: food, energy, waste, water and personal transport. The survey was implemented in 10 OECD countries (Australia, Canada, Czech Republic, France, Italy, Korea, Mexico, Netherlands, Norway and Sweden).[2] About 10,000 respondents were recruited using a web-based access panel, managed by a private company that specializes in web-based panels. The company recruits respondents to become members of a panel by screening respondents for demographic characteristics in order to obtain a panel that is representative of a population. For this particular survey, the sample was stratified according to age, gender, income and

[2] The translations of the survey into the different languages were checked by the research teams that were responsible for the analysis (one in each country) in order to make sure that the questions were well understood.

region in each of the 10 countries. Once recruited, chosen panel members are contacted by email and invited to respond to selected surveys.[3]

Internet use and access is high in all countries in the sample of our study, but for the Czech Republic and Mexico. Care was thus taken in choosing the sample size for those countries. For example, the sample size for the Czech Republic was around 700, as the survey provider could not assure that a higher number of respondents would be representative. As found in OECD (2009), the data for the Czech Republic actually corroborated well with national statistics on socio-economic characteristics, as was the case for most of the other countries. The one exception where they may be a concern is with Mexico, for which the data corroboration indicates that the Mexican sample in the OECD survey is younger, wealthier and better educated than expected. This is quite likely a result of the fact that internet use is not widespread, neither in a geographic context, nor in a socioeconomic context.[4]

Web-based surveys are increasingly used as a means to implement targeted surveys at a relatively low cost compared to in-person interviews. Lindhjem and Navrud (2008) recently compared web-based surveys with in-person interviews in a controlled field experiment on the same panel of respondents and found no significant biases in the web-based survey compared to the interview survey. Kiernan et al. (2005) compared a web-based survey with a mail survey and found that the web-based survey had better response rates and the same question completion rate as the mail survey and that there was no evidence of evaluative bias. The same conclusion was reached by Fleming and Bowden (2009) who compared response rates, socio-demographic characteristics, and surplus estimates of respondents obtained from conventional mail and web-based surveys. So far, the results thus seem quite encouraging as to the validity of this type of survey instrument.

In the OECD questionnaire, the respondents were surveyed on a set of environmentally relevant activities including use of water and energy, recycling, transportation mode. In what follows, we study the likelihood that households had invested during the last 10 years or were

[3] An algorithm conducted by MARSC software (http://www.marsc.com) is used to select respondents based on stratification variables and the panel management rules (for example taking into account the maximum number of surveys a panelist can respond to each year). In order to avoid fraud, potential panelists IP addresses are checked, computers are tagged to ensure only one registered response per computer, and respondents' postal addresses are verified. Further details on the sampling procedure can be found at the following address: http://www.oecd.org/dataoecd/55/19/44101274.pdf.
[4] We will test the robustness of our estimation results to the removal of the Mexican sub-sample.

already equipped with (1) a water-efficient washing machine, (2) low volume or dual flush toilets, (3) water flow restrictor taps or low flow shower heads, and (4) water tanks to collect rainwater. Respondents were also asked a series of questions regarding characteristics of their household (age, income, composition, education, ownership status), housing characteristics, and behavioural attitudes or opinions regarding the environment in general. A selection of these questions as well as the specific questions on water use can be found in Appendix A1.

3. Modeling framework

3.1. Adoption model

The underlying economic model assumes that each household will adopt equipment *j* as long as its expected indirect utility with adoption over the lifetime of the equipment, $\mathrm{V}_j^1(.)$, is greater than its expected indirect utility without adoption, $\mathrm{V}_j^0(.)$. Under the assumption that the indirect utility function $\mathrm{V}_j^k(.)$ can be written as the sum of a deterministic component $\mathrm{V}_j^k\left(\mathbf{x},\boldsymbol{\beta}_j^k\right)$, *k=0,1*, where $\mathbf{x}$ is the vector of observable factors that drive the household's decision, and a random term of mean 0, ε_j, the household will adopt equipment *j* if and only if:

$$\mathrm{V}_j^*(\mathbf{x}) = \mathrm{V}_j^1 - \mathrm{V}_j^0 = \mathbf{x}'(\boldsymbol{\beta}_j^1 - \boldsymbol{\beta}_j^0) + \varepsilon_j^1 - \varepsilon_j^0 = \mathbf{x}'\boldsymbol{\gamma}_j + \omega_j > 0\,. \quad (1)$$

We define a dichotomous variable ADOPT_j (for adoption of equipment *j*) which is equal to 1 if $\mathrm{V}_j^* > 0$ and 0 otherwise. Under the assumption that ω_j follows a standard normal distribution of variance 1, we obtain the following Probit type model:

$$\mathrm{Prob}(\mathrm{ADOPT}_j = 1 \mid \mathbf{x}) = \mathrm{Prob}(\mathbf{x}'\boldsymbol{\gamma}_j + \omega_j > 0 \mid \mathbf{x}) = \Phi(\mathbf{x}'\boldsymbol{\gamma}_j) \quad (2)$$

where Φ is the standard normal distribution function. Under the assumption of normality of the error term, the Maximum Likelihood method provides consistent and efficient estimates.

We will estimate four such Probit models of a household's probability of investing in the four different equipments in the survey: water-efficient washing machines (Model 1), low volume or dual flush toilets (Model 2), water flow restrictor taps or low flow shower heads (Model 3) and water tanks for collecting rain water (Model 4). The dependent variable takes the value 1 if the household has invested in the equipment during the last 10 years or was already equipped. If this approach seems reasonable for the case of the water tank or the low flow shower head for which technology may not have really changed over the past 10 years, the performance of water-efficient washing machines may have significantly improved in 10 years. For this reason, we will test the robustness of our results by considering a slightly different definition of the dependent variable (Model 1bis): the dependent variable is set equal to 1 if the household has invested in a water-efficient washing machine during the last 10 years and 0 if it has not or if it was already equipped.

We do the estimations first on the pooled data controlling for country-specific effects, and next, we also undertake the same estimations country by country. The country-specific effects may capture country-specific behaviour/consciousness related to water use, water-specific policies that have been put in place by the national governments, or may reflect the supply side of the market for water-efficient devices (water-efficient equipment may be cheaper or easier to find in some countries than in others).

3.2. Factors hypothesized to influence adoption

Studies on adoption of water-efficient appliances are quite rare so we will discuss factors influencing water conservation activities in general, including behavioural change (turning off the shower when soaping up, only using dishwashers and washing machines with a full load). Water conservation activities are influenced by the socio-economic characteristics of the household, such as education, income, and home ownership, as well as by policy and by attitudinal variables such as opinions about the environment in general. The few existing studies of adoption of water-efficient appliances have mainly controlled for socio-economic variables, whereas the evidence on attitudinal variables mainly derives from studies of intentions to reduce water use by changing behaviour.

Socio-economic variables

Except in Renwick and Archibald (1998), who analyse household data from two communities in California (Santa Barbara and Goleta), home ownership is found to increase household's water conservation activities in general (Berk et al., 1993, on 600 Californian households; Gilg and Barr, 2006, on 1,265 households from Devon, England).[5] Knowing that owners usually pay their water bills (while this is not always the case for renters) and that only the owner will reap the long term benefits of the investment (that eventually may be capitalised into the real estate price), we expect owners to be more likely to install water-saving devices. We will test this hypothesis on our data.[6]

There is no clear evidence on the impact of income on water conservation. Renwick and Archibald (1998) find a significant and positive effect of household income on the number of indoor water-efficient equipments (low-flow shower heads and low-flow toilets) while a higher income decreases the probability of using a water-efficient irrigation technology. An analysis of census tract data in San Antonio, Texas, over the 1995-1997 period actually found that high income is negatively correlated with conservation (De Oliver, 1999). This result may seem counterintuitive and may be related to the use of aggregate data. Finally, Domene and Sauri (2006) finds that water conservation behaviour of households in the metropolitan region of Barcelona (installing water-saving devices in taps, toilets, and showers, turning off running water while brushing teeth, purchasing water-efficient appliances, and comparing water consumption between periods) does not tend to depend on income, with the only exception being shower use, for which income had a positive effect. The impact of income on the adoption of water-efficient equipment is ambiguous ex ante (Hausman, 1979). On the one hand, some equipment entails high investment costs that only richer households may be able to afford it (in an incomplete credit market), but on the other hand, given the diminishing marginal utility of income, richer households may value savings less than poorer households. The opportunity cost of time is also higher for a rich household, and in the extreme case, low income households with a low opportunity cost of time may install water-saving devices themselves. We thus have no a priori hypothesis on the impact of income on the adoption of water-efficient equipment.

[5] Gilg and Barr (2006) did not study the adoption of water-efficient equipment, only behavioural change.
[6] The same type of arguments is found in most analyses of energy-efficiency appliances (Sutherland, 1991).

The influence of education is also ambiguous. We would expect education to increase adoption of water-saving devices since households with higher education are more likely to understand/be aware of the nature of the water shortages and to understand/be informed about the water-saving options (Berk et al., 1993). The positive influence of education on water saving behaviour was confirmed in Gilg and Barr (2006). However, in surveys conducted in Taiwan, Republic of China, in 2002 and later in 2004 on a different sample,[7] Lam (2006) found that higher education positively affected intentions to adopt a dual-flush controller in one sample but not in the other. A priori, we expect education to influence adoption of water-efficient equipment positively.

In the subsequent empirical analysis, we will be able to control for a set of demographic variables including ownership status, income, age and gender of the respondent, education, and household size. We will also include some variables on dwelling characteristics: size of primary residence (in squared meters), size of garden/balcony/terrace (in squared meters), number of rooms and age of the residence. We are not aware of any previous studies that analyse the impact of dwelling characteristics on the probability to adopt water-efficient equipment, but there are some indications from analyses of water and energy *consumption*. Our null hypotheses are that the size of the garden increases the probability to adopt water tanks to collect rainwater, and that the size of the residence and the number of rooms should increase the probability to adopt indoor water-efficient equipment. As concerns the age of the dwelling there are two effects: on the one hand, the older the building the more likely it is to include inefficient equipment that increases water use.[8] On the other hand, the high water consumption of an old dwelling makes it more economically efficient to retrofit it. We retain a positive effect of dwelling age as a null hypothesis to test on the data. We also include the squares of residence size and age in order to test for non-linear effects.

Attitudinal and behavioural factors

Efforts at measuring environmental attitudes and behaviour are limited by possible biases related to self-reported attitudes and behaviour: a socially desirable habit is more likely to be over-reported by households. Although positive intentions to reduce water use do not

[7] The two samples differed significantly as concerns education and income.
[8] Nauges and Thomas (2000) show a positive effect on water consumption from a higher proportion of old residences (built before 1949) and a negative effect of the proportion of housing built after 1982. Nesbakken (2001) found that the age of the dwelling increased residential energy consumption.

correspond to actual reductions, we will nevertheless summarise the research on behavioural intentions since this is what existing studies on environmental attitudes and water conservation analyse. Commonly, behavioural intention is assumed to depend on two variables: the individual's attitudes towards behaviour and the individual's subjective norms relating to the perceived normative pressure to adopt the behaviour (Fishbein and Ajzen, 1975). Extended models also include the actor's perceived behavioural control - that is, the perceived difficulty of performing the behaviour, response efficacy, or perceived threat (severity of the water shortage). All these variables are typically measured by survey questions with answers on a 5- or 7-point Likert scale, indicating agreement or disagreement with a statement or question.

A perceived environmental threat, such as strong perceptions of the severity of a water shortage, has been found to be closely related to intentions to conserve water by changing behaviour (Kantola, Syme and Nesdale, 1983; Gilg and Barr, 2006; Lam, 2006). In a survey of Kaoshiung residents (Taiwan), it was found that a strong perception of environmental threat, a strong belief in the efficacy of adopting a dual-flush controller compared to alternative strategies, a high estimation of the number of other residents that would take action to save water, and a high estimation of the money that could be saved by adopting a dual-flush controller, significantly contributed to positive intentions to adopt a dual-flush toilet (Lam, 2006).[9] Gilg and Barr (2006) find that water savers are more likely to perceive an environmental threat and to be aware of a social norm to conserve water (the example of friends and neighbours), whereas non-environmentalists express greater belief in their rights to use water according to their own demand. Finally, in their analysis of water conservation behaviour, Domene and Sauri (2006) found that households with a higher score on the index measuring water conservation habits reduced their water use between 4.3 and 4.6 litres per capita per day.[10]

The OECD survey includes questions about households' attitudinal and behavioural factors measured on a 5-point Likert scale. From these answers, we build three indices that correspond to the individual means computed from the "applicable/possible answers", i.e., we

[9] Two separate samples were studied. The variables that have been found significant vary from one sample to the other. For more details, see Lam (2006).
[10] The reduction was only statistically significant in the winter period, though, since no outdoor water-saving device was included in the index and the climate tended to increase outdoor water use to a large extent during the summer season (because of gardens and swimming pools).

calculate the mean score for each individual only taking into account the sub-questions that she answered (see Appendix A2 for the calculation of these indices).[11] We have one such attitudinal index, *index_env_concern*, that measures environmental concern in general (including among others concern about waste generation, air pollution, climate change, and water pollution), not just about water use, and could be interpreted as a proxy for the perception of a general environmental threat. We then have two behavioural indices: *index_green_prod*, that measures purchases of green products in general (not related to water), and *index_habit_water*, an index measuring the respondent's habits to conserve water (turning off the water while brushing teeth, taking showers instead of baths, plugging the sink when washing the dishes, among other examples).[12] For these three indices, a higher value of the index indicates a higher degree of environmental consciousness or commitment.[13] We also include in the adoption models two dummy variables indicating whether the respondent devotes time to an environmental organisation (variable *i_time_orga*) and whether the respondent is a member of or has donated money to such organisations (variable *i_member_orga*). We expect more environmentally-committed respondents to be more likely to adopt water-efficient equipments.

Policy Variables

Labelling

We have not found any empirical study on the impact of eco-labels on durable goods, such as water-efficient equipment. This particular question will be addressed in the forthcoming empirical application since the households were surveyed about several labels including European Union, Nordic or national eco-labels, according to the specific country, or specific

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[11] See Lam (2006) for a similar approach. We also tried to build indices using Principal Component Analysis. The indices built following the sample mean approach were found to be more significant in general. Factor analysis is another possible technique for aggregating answers measured on a Likert scale (Gilg and Barr, 2006).

[12] We also started out by including a fourth index created from the survey and representing attitudes towards the solutions of environmental problems – for example, whether the individual household can contribute, or whether governmental policies addressing environmental problems should not entail supplementary costs to the household - but this index was never significant and was excluded in the final estimation that is presented here.

[13] These three indices will be treated as continuous variables, which relies on the underlying assumption that the ordering is linear: for example, if possible answers are "never", "occasionally", "often", and "always", we assume that moving from "never" to "occasionally" is equivalent to a move from "often" to "always". Instead, one could have considered separately the answer to each separate item and build dummy variables corresponding to each answer and each item. For example, regarding the index measuring households' habits to conserve water, we could have built four dummy variables to describe whether the respondent would turn off the water while brushing teeth: "never", "occasionally", "often", or "always", and the same for "taking showers instead of bath", "plugging the sink when washing the dishes", etc. However, such a procedure would have increased significantly the number of parameters in the adoption models as well as the risk of multicollinearity.

water efficiency labels, if applicable. We construct a variable that measures whether the household takes the labels into account in its purchasing decisions (all kind of purchasing decisions, not only water-efficient devices). A priori, we expect this variable to increase the probability to adopt water-efficient equipment.

Water charge and metering

Renwick and Archibald (1998) find a strong and significant positive effect of the marginal price for water on the number of water-efficient equipments in the household. These results seem to contradict the findings of Syme, Nancarrow and Seligman (2000) who, in a survey of the research on attitudes and water conservation, concluded that monetary savings are not a large factor in water conservation (at least as long as water is underpriced), and that subjective norms or other socially motivated values are more important in strengthening behavioural intentions to conserve water. Apart from these two surveys, and as far as we know, the effect of the price of water on installation of water-saving devices has never been studied. A price increase (or an expected price increase in the future) could however be one motive for investing in water-efficient devices since the use of water appliances has a direct impact on the water bill when households are charged for water.[14]

We are not aware of any study of the particular effect of metering on the adoption of water-efficient appliances, but scenario studies of the impact of individual metering in Southern England found evidence of greater willingness to conserve water when water use was known to be metered rather than unmetered (Van Vugt and Samuelson, 1999). The study also analysed self-reported conservation behaviour of households in the same area but did not find any statistically significant effect between metered and unmetered households, though.[15]

In the forthcoming empirical application, we will take advantage of the heterogeneity among the 10 countries to measure the impact on adoption of water-saving devices of paying a

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[14] Even if water demand has been found inelastic to price in the bulk of water demand studies, household water use, in all cases, do respond significantly to price variation, though in a moderate manner (residential demand being price inelastic is a technical definition meaning that a one-percent increase in price results in a less than one-percent decrease in consumption). For comprehensive reviews, see Arbués-Gracia, García-Valiñas and Martínez-Espiñeira (2003).

[15] This result may depend on the absence of control variables for the demographic differences between the samples of metered and unmetered households, or on possible self-reporting bias in the responses of the unmetered households.

volumetric charge and of being metered. We build a categorical variable that distinguishes respondents who are not charged for water, those who are charged for water but not metered, and those who are charged for water and metered. We will not use a measure of the price of water per se because information on the price charged for water is missing in many cases, either because households do not pay for water (or because water charges are part of the rent) or because they were not able to report this information at the time of the survey. Being unable to consider the price of water as a determinant for adoption is not a major drawback though, since economists and policy makers usually agree that households are rarely well informed about the price of water.[16] We hypothesize that volumetric pricing and individual metering of water use, linked with individual billing, will increase the likelihood of installing water-efficient devices by imposing the marginal cost of water on the household, and by providing feedback on the efficacy of water reduction strategies.

Non-price policies

Non-price policies for water management include water restrictions on specific uses (such as irrigation or car washing), information and education campaigns to encourage water conservation, and rebates for adoption of water-efficient technologies. The role of subsidies or campaigns that promote the use of water-efficient devices has rarely been studied, mainly because of lack of appropriate data. Exceptions are Renwick and Archibald (1998) and Renwick and Green (2000) that analyse data on California's experience with such policies during severe drought episodes at the end of the eighties, and Campbell, Johnson and Hunt Larsen (2004) on demand side management policies in Arizona.

Renwick and Archibald (1998) find that restrictions imposed on the use of irrigation water had a significant and positive effect on the probability of using an efficient landscape irrigation technology but also on the number of indoor water-efficient equipments used by households. Renwick and Green (2000), using data from eight Californian water agencies over the 1989-1996 period,[17] found that more stringent mandatory policies were more effective in reducing water use than voluntary measures: water rationing and use restrictions

[16] Domene and Sauri (2006), using a sample of 532 households from 22 municipalities in the metropolitan region of Barcelona, observed that almost half of the interviewed households did not look at the water bill or compared it with previous bills, and that most of customers did not understand the tariff schedule of their municipality.

[17] San Francisco Water District, Marin Municipal Water District, Contra Costa Water Agency, East Bay Municipal Utility District, City of San Bernardino, City of Santa Barbara, Los Angeles Department of Water and Power, and City of San Diego.

were found to induce a reduction of 19 and 29% respectively while public information campaigns and retrofit subsidies were found to reduce average household use by 8 and 9% respectively.

Campbell, Johnson and Hunt Larsen (2004) study the impact of regulation and non-price conservation programs undertaken by the city of Phoenix, Arizona, during the period 1990-1996. They found a water reduction of 3.5% from regulation imposing the installation of low-flow fixtures and devices, but increases in water use from free retrofit device kits (to the order of 3.8-4.6%). Another policy had similar devices installed on personal house visits with person-to-person communication and it obtained significant savings between 2.4 and 6.4%. The result may depend on the difference between receiving equipment for free and actually installing it. Nevertheless, the results of Campbell, Johnson and Hunt Larsen (2004) raise the issue of a possible rebound effect, i.e., an increase in water use following the installation of water-efficient equipment. This issue has been much studied in analyses of household adoption of energy-efficient equipment, where it indicates the possible increase in consumption following a reduction in the effective price of energy services brought about by energy efficiency improvements. Recent evidence seems to indicate that the rebound effect on energy use is limited: 0-15% on data from the Netherlands (Berkhout, Muskens and Velthuijsen, 2000), 0-6% on data from Sweden (Brännlund, Ghalwash and Nordström, 2007) whereas Japanese household data indicate a rebound effect of the magnitude of 27% (Mizobuchi, 2008).[18] A significant part of potential savings thus seem to be realized, but the evidence calls for the use of combinations of instruments, for example price instruments in combination with efficiency improvements in order to limit any potential increases in consumption. Although the aim of our study is not to assess the actual water use reductions obtained, later on we will discuss some evidence from our data that lead us to consider the risk of a potential increase in water use as limited.[19]

[18] Recent empirical estimates of the rebound effect take into account changes in the capital cost of the energy-using equipment, which significantly reduces the extent of the rebound effect. See Sorrell and Dimitropoulos (2008) for a recent review of different definitions of the rebound effect and a very useful discussion of their implications for empirical estimates.

[19] There exists little empirical evidence on the impact of water-efficient devices on household water use. Renwick and Archibald (1998) show that the use of one low-flow toilet decreases household water use by 10% while the use of one low-flow shower head results in a 8% decrease in household water consumption. Water-efficient irrigation technologies reduce water use by 11%; traditional irrigation techniques, on the other hand, increase water usage by 9%. Kenney et al. (2008), in an analysis of household data from Colorado over the period 1997-2005, show that rebates to indoor water-efficient equipment, such as low-flow toilets and water-efficient washing machines, reduced household water demand by 10%.

Some households in our sample may have benefited from government support to invest in water-efficient devices. Unfortunately, only households who first declared owning a water-efficient equipment were questioned about subsidy programs. The information on government support is thus incomplete and cannot be used as an explanatory factor in the adoption models.

We summarize in Table 1 the main findings of the previous studies on factors that influence water conservation behaviour.

4. Summary statistics and estimation results

4.1. Summary statistics

The list of explanatory factors that are considered in the econometric analyses and the sample mean of each variable (for the entire sample and for each country separately) are given in Appendix (Table A1 and Table A2 respectively).

About half of the respondents (in the overall sample) are equipped with a water-efficient washing machine, low volume or dual flush toilets, and a water flow restrictor tap or a low flow shower head (Table 2).[20] Fewer respondents are equipped with a water tank to collect rainwater. This share is 17% on the full sample, and varies from 4% in Norway to 34% in the Czech Republic. For indoor water-efficient equipment we can clearly see the impact of water scarcity constraints. The high adoption rates in Australia and Mexico reflect the government sponsored programs to introduce such equipment in order to reduce water consumption. Water abundant countries, on the other hand, generally display lower rates of adoption. The Netherlands, the only country apart from Australia to have a separate water efficiency label, has a high rate of adoption of all three indoor water efficiency devices. The Czech Republic, that displays the highest rate of adoption of water flow restrictor taps, has experienced large water price increases over the last 10 years. The French rates of adoption of water-efficient washing machines and low volume toilets are also among the highest, and may reflect the fact that the French average price of water is the relatively highest by comparison with the other countries. On the whole sample, 21% of the surveyed households do not own any of the four

[20] For each of the four water-efficient devices, we do not know if the household owns only one or more than one equipment.

equipments (Table 3). This percentage varies from 9% in Australia to 43% in Korea. Only 8% of the entire sample own the four equipments. In Table 4, we provide greater details on the number of households owning one, two, three or four types of equipment. These figures indicate that owning the three indoor equipments is quite common in most countries while owning only a water tank is unusual.

For the few countries where we could find statistics on households' installation of water-efficient equipment, the official statistics corroborate some of the numbers from the OECD survey. In 2007, 39% of Canadian households report having a low-volume toilet (Statistics Canada, 2009), whereas the corresponding figure is 40% in the OECD survey. In the same year, 54% of Canadian households reported having a low flow shower head (56% in the OECD sample, which also includes water flow restrictor taps). In Australia, the statistics from 2004 (Australian Bureau of Statistics, 2006) indicate that 73% of households used a dual flush toilet (75% in the 2008 OECD survey), and that 44% used a low-flow shower head (the corresponding figure in the OECD survey is 63% but it also includes water flow restrictors in general).

On the full sample, 63% of the households are charged and metered for their water use, 13% are charged a flat fee (not metered) and 24% are not charged at all for their water use (see Table A2). There are large differences between countries, with the lowest proportion of metered households occurring in countries known as "water-abundant": Norway, Sweden and Canada. Simple statistics indicate that 8% of the households who own a water-efficient washing machine benefited from some government support. For low-volume or dual flush toilets, water flow restrictor taps and low flow shower heads, and water tank, the corresponding figures are 7%, 9%, and 10%, respectively. A closer look at the data shows that in all 10 countries some households benefited from government support to invest in a water-efficient device. However, government support seems to be more frequent in Australia, Canada, Italy, and Mexico. Finally, national water labels exist only in Australia and in the Netherlands, and a higher percentage of households state that they take the specific water efficiency label into account in Australia (66%) than in the Netherlands (12%).

4.2. Estimation results

Models (1), (2), and (3) describing adoption of indoor water-efficient equipments (efficient washing-machine, low volume or dual flush toilets, and water flow restrictor tap or low flow shower head, respectively) are estimated using 9,439 observations while the model describing adoption of water tanks is estimated using 9,437 observations.[21] Non-linear effects of the continuous variables (age of the residence, surface of the residence, surface of the garden/balcony/terrace, number of rooms, income) were tested and kept in the models if significant. The estimated coefficients and standard errors obtained from application of the Maximum Likelihood estimator on Models 1 to 4, on the pooled data, are shown in Table 5, and the corresponding marginal effects are in Table 6.[22] Some diagnostic tests, including the outcome of the likelihood-ratio test and the percentage of correct predictions (for the whole sample, the sub-sample of adopters, and the sub-sample of non-adopters) are reported in Table 7. We also tested for multicollinearity by computing the variance inflation factor (VIF) in the four models (Table 7).[23]

Among the socio-economic variables, ownership status, the size of the household, and income are always significant at a 5 percent level (see Table 5). The education level is never significant, and is not included in the final estimation, for the main reason that education level is correlated with income. The gender of the respondent is not significant either, and it was also excluded from the final estimation that is presented in Table 5. Ownership status always has a positive impact on adoption of water-efficient equipment, which is in line with theory and most empirical findings from the literature but opposite to Renwick and Archibald's (1998) findings. The marginal effect (on the probability of adoption) of being an owner varies between 0.06 and 0.10, and is among the highest marginal effects in the four models.

The second largest marginal effect among the socio-economic and demographic variables is household size, which has a positive effect on adoption of all four equipments (we observe a concave relationship between household size and the probability to own an efficient washing-

[21] We consider all households in the fourth model and not only households with a garden, balcony or terrace since water tanks can also be installed on the roof. In our sample, 110 respondents declare having no garden/terrace/balcony and at the same time using a water tank to collect rainwater.
[22] Estimation results of the four models were found to be robust when households from Mexico were excluded from the sample.
[23] The VIF is an indicator of how much of the inflation of the standard error could be caused by collinearity. If all the variables are orthogonal to each other, the VIF is 1. As a rule of thumb, a VIF of 10 or greater is a cause of concern.

machine). Household size can be interpreted as an indicator of water use, and thus potential water savings from adopting water-efficient equipment. Interestingly, we find exactly the same effect of income as Renwick and Archibald (1998): a positive influence on the probability to install indoor water-efficient equipments but a negative influence on the probability of buying a water tank. This result could indicate that households who equip themselves with a water tank do so for money-saving purposes. But, it should be noted that the marginal income effects, though significant, are always close to zero.

Certain characteristics of the dwelling - number of rooms, size of the garden/balcony/terrace - have a positive and significant impact on the probability of adopting water-efficient equipment. For water tanks, unsurprisingly, the external surface is the only variable to have a significant positive effect on adoption, though. By contrast, the age of the dwelling has a negative significant impact on the adoption of water-efficient equipment. Our null hypothesis that dwelling age should increase the probability to adopt water-efficient equipment is thus refuted. For low volume or dual flush toilets, and for water tanks, there is a positive effect of age squared that indicates that below a certain age retrofitting is not considered efficient, but above this age the older the building is the more likely it is to be fitted with these types of water-efficient equipment. Nevertheless, the observations in our sample are always in the interval where the marginal effect of the age of the dwelling on the probability to own these two equipments is negative. For the other types of indoor equipments, the squared variable was not significant and (again) the older is the dwelling the lower is the probability of retrofitting.

The main contribution of our paper is to assess the relative impact of socio-economic, attitudinal, behavioural, and policy variables. As concerns the variables measuring attitudes and behaviour, the results are quite strong. Environmental commitment as displayed by the index of purchases of green products or the index of water conservation habits affect adoption of water-efficient equipment to the same extent as ownership. More precisely, a marginal increase in the index of purchases of green products increases the probability of adopting indoor water-efficient equipment by 0.09 on average. As for the index of water conservation habits, its marginal effect on the probability of adoption varies from 0.04 in the case of water tanks to 0.13 in the case of the water flow restrictor taps/low flow shower heads. By comparison, the index representing environmental attitudes in general is only significantly positive for the adoption of water flow restrictor taps, but it has a much smaller impact than the index representing environmental purchase habits. These results are in line with the degree of commitment expressed by each index, since purchasing environmentally friendly products represents a stronger level of commitment than simply expressing positive environmental attitudes, although one would expect a correlation between the two. The behavioural variables are thus some of the strongest factors for adoption. With caution due to the fact that these results rely upon stated behaviour, we find a clear pattern: the impact on the adoption of water-efficient equipment increases with the degree of commitment expressed by each index. This result, in addition to the fact that few households (8-10%) benefited from government support when investing, indicate that any potential rebound effect from the adoption of water-efficient equipment should be limited. The households had to incur some (monetary) effort to obtain the equipment and the ones that do so state that they follow water conservation habits in their daily life and are thus likely to take more care in their water consumption. In fact, rough estimations of the costs and benefits to an individual household of installing water-efficient equipment indicate that money savings may not be a primary motivation for adopting such equipment. Table 8 shows some simple calculations based on estimations of water savings and costs provided by the Australian government.[24] We argue that this kind of calculation is consistent with our results that adoption is largely determined by environmental behaviour and attitudes rather than income.

Community involvement by devoting time to environmental organisations increases the probability of adopting water flow restrictor taps or water tanks, whereas being a member of or donating money to an environmental organisation contribute positively to explaining the adoption of water-efficient washing machines and water tanks. Compared to the indices on green product purchases and water-saving behaviour, there is no clear pattern, though, and the impact is much smaller.

The policy-related variables display a different impact according to the type of equipment, with a clear distinction between indoor and outdoor water-efficient equipment. Households that are both charged and metered for their individual water use are more likely to adopt indoor water-efficient equipment, whereas the impact on the adoption of water tanks to collect rainwater is not significant. The marginal effect of being charged for water and metered varies from 0.07 to 0.10 for the three indoor equipments, and is higher than the marginal effect of

[24] Such figures were only found for one of the countries in our sample.

being charged but non-metered (from 0.03 to 0.05). These findings indicate that the price of water has an effective signalling role on the value/scarcity of the resource but also that this signal will be even more effective if the household is charged based on its consumption. These results thus confirm the effectiveness of individual metering to encourage the adoption of water-efficient equipment.

If the respondent took the appropriate environmental label into account in his or her purchasing decisions, this increased the probability of adopting indoor water-efficient equipment, but had no effect on the adoption of water tanks. The impact of the labels is the most important for the adoption of water-efficient washing machines and water flow restrictor taps. The marginal effect of labels is comparable to the marginal effect of being charged for water with a flat fee (0.03-0.06).

Specific country effects are controlled for by country dummy variables. Australia has been chosen as the country of reference in the four models. As concerns water-efficient washing machines, the dummy representing the Netherlands has a positive impact on the probability of adoption, whereas the impact is significant and negative for the Czech Republic, Korea, Norway, Canada and Sweden. For low volume toilets, a location in Korea, Italy, Norway and Canada have the largest negative impact on the probability to adopt compared to the reference country Australia. For this particular equipment, the results may be taken as cautious evidence of a smaller probability of adoption in water abundant countries. For water flow restrictor taps, Canada, Italy, and Sweden display no different impact than Australia. We find significant negative country-effects in France, Korea and Mexico, and significant positive effects in the Czech Republic, the Netherlands and Norway. As for water tanks, all country-specific effects are negative except for the Czech Republic. These country-specific effects may capture the effect of missing variables such as water-specific policies that could have been put in place by the national governments and in particular rebate programs to encourage adoption of water-saving devices. For example, among the countries in the sample, Australia and Mexico have implemented specific programs in situations of extreme water shortage whereby the government sponsored the installation of water-efficient devices. Also, the country dummies may reflect country-specific characteristics of the market for these equipments. In particular, the price at which these equipments are sold may vary across the 10 countries.

In order to account for the shorter economic lifetime of water-efficient washing machines, we also consider another definition of "adopters" for this particular equipment: the dependent variable is set equal to 1 if the household has invested in a water-efficient washing machine and 0 if it has not or if it was already equipped (model 1bis – not presented here). The results are quite robust with respect to this modification. The indices of water conservation habits and of green product purchases decrease somewhat in size, but remain at the same level of statistical significance. The impact of household size increases. The percentage of correctly classified decisions slightly decreases, though, so we prefer the standard Model 1 for the adoption of water-efficient washing machines. We now turn to the specific estimations performed on each individual country sample.

Each of the four models is estimated separately for each of the 10 countries. We will only comment on the main driving factors of adoption, namely ownership status and the behavioural variables.[25] The country-by-country analysis confirms the important role of ownership status: being an owner always has a positive impact on the probability of adopting the four water-efficient equipments across countries, even if the variable is not significant in some cases. In each country, this variable is significant for at least one type of equipment. The index of water conservation habits is always positive and significant in explaining the adoption of water-efficient washing machines except for Canada, the Czech Republic and Sweden, Sweden for low volume toilets, and except for Italy, Norway and Australia for water tanks. Likewise, the index for purchasing environmentally friendly products is always significant and positive for all equipment, except for the Czech Republic and Korea for water-efficient washing machines, the Czech Republic and Australia for low volume toilets, Italy and Australia for water flow restrictor taps, and the Netherlands, France, Italy, the Czech Republic, and Korea for water tanks. By comparison, the index of environmental concern (perception of environmental threat) is only significant in one or two countries for each equipment type.

5. Conclusion and policy implications

Using original survey data of approximately 10,000 households from 10 OECD countries, we assess the relative impact of socio-economic, attitudinal, behavioural, and policy variables on

[25] The full country specific results are available from the authors upon request.

household adoption of water-efficient equipment. The results indicate that the adoption of water-efficient equipment is the most strongly affected by ownership status, by being metered and charged a volumetric price on water consumption and by behavioural factors. In particular, we find that a strong commitment to environmental values, such as displayed in the index of purchases of green products, or the index of water consumption behaviour, increases the probability to adopt indoor water-efficient equipment by 0.09 on average. This is the same order of magnitude as for ownership status that has a marginal effect ranging from 0.06-0.10. The index of water consumption habits increases the probability of adoption from 0.04 in the case of water tanks to collect rainwater to 0.12 in the case of water flow restrictor taps and low flow shower heads.

Adoption is of course also strongly affected by socio-economic variables. Apart from ownership status, that encourages adoption to the largest extent, we find a significant positive effect of household size for all four equipments studied in the survey. Somewhat surprisingly, we find very small – although significant - effects of household income. Other variables, though, like the number of rooms of the residence, that may be proxies to household wealth, have a larger impact on adoption, but never as large as ownership.

In terms of policy variables, we assessed the impact of the water charging system, i.e., whether the household is charged for its water consumption and whether it is metered individually, and thus pays a volumetric fee, or whether it pays a flat fee, and the impact of applicable environmental labels. In general, households display bad knowledge of their water bill. This suggests that the price of water as such is not sufficient to explain the adoption of water-efficient equipment. On the other hand, we find a clear-cut result of *the structure of water charging* in terms of metering or not. Households that were both metered and charged for their water individually (volumetric fee) have a much higher probability of investing in the three types of indoor water-efficient equipment studied in the OECD survey compared to households that are not charged for their water (the estimated marginal effect varies from 0.07 to 0.10), or, to a smaller extent, compared to households that are charged but not metered individually for their water (flat fee). The effect was not significant for water tanks to collect rainwater. These results would strongly indicate the need for more information, both in terms of more widespread introduction of individual metering – and the introduction of volumetric charges - and in terms of more information on water uses on the bill.

The other policy variable assessed here is labelling, when respondents indicated that they took labels into account in their purchase decision. Our estimation results suggest that the marginal effect of a label on the adoption of water-efficient washing machines and water flow restrictor taps is slightly smaller than the effect of moving from not being charged to being charged a flat fee for water (the marginal effect of labelling ranges from 0.03 to 0.06 for the three indoor water equipments).

As regards policy implications, our results clearly indicate the importance of introducing volumetric charging of water consumption in order to encourage the adoption of water-efficient equipment. Other non-price policies, such as eco-labels, do induce adoption of such equipment but to a smaller extent. We also conclude that the households that voluntarily adopt such equipment are the ones that display strong environmental values by already purchasing environmentally friendly products or stating water-saving habits. This last result is important since it suggests that the households that invest in such equipment are less likely to increase their water consumption following adoption, given that they are the households that already display care in their water use. Any potential rebound effect from the adoption of water-efficient equipment should thus be small.

Future research could extend the analysis in different ways. Due to the construction of the survey used here, we could not assess the relative effectiveness of direct regulation (water use restrictions) on the adoption of water-efficient equipment. The relative efficiency of economic variables versus direct regulation on the adoption of water-efficient equipment is thus an open issue. Nor could we assess the effectiveness of public subsidies on the adoption of water-efficient equipment, since the question was only asked to the households that had invested in such equipment. An analysis including these additional factors would be a topic for future research on household adoption data.

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Tables

Table 1. Main effects on water conservation behaviour from the previous empirical or theoretical literature

Variables	Sign of the effect	References
Socio-economic variables		
Age	+	Gilg and Barr (2006)
	n.s.[(a)]	Lam (2006)
Education	+	Berk et al. (1993) Gilg and Barr (2006)
	-	De Oliver (1999)[(b)]
Income	+	Berk et al. (1993) Renwick and Archibald (1998) for indoor equipment Lam (2006) in one sample
	-	Renwick and Archibald (1998) for outdoor equipment
	-	De Oliver (1999)
	n.s.	Lam (2006) in one sample
Ownership	+	Berk et al. (1993) Gilg and Barr (2006)
	-	Renwick and Archibald (1998) for some indoor equipments
	n.s.	Renwick and Archibald (1998) for some indoor equipments and for outdoor equipment
Characteristics of the dwelling		
Age	+	Nauges and Thomas (2000)[(c)]
Size/number of rooms	+	Dandy, Nguyen and Davies (1997)[(c)]
Attitudinal and behavioural factors		
Perception of environmental threat	+	Kantola, Syme and Nesdale (1983) Gilg and Barr (2006) Lam (2006)
High estimation of money savings	+	Lam (2006)
Water conservation habits	+	Domene and Sauri (2006)
Policy variables		
Metering	+	Van Vugt and Samuelson (1999)[(d)]
Labelling	+	According to theory, but empirical evidence missing

Notes: (a) n.s. is for “not significant”. (b) The study concerned water conservation in general and not adoption of water-efficient equipment specifically. (c) The studies show a positive impact on water consumption, which in turn should increase the economic efficiency of adoption. (d) The results concern the willingness to conserve water (and not specifically adoption of water-efficient equipment).

Table 2. Share of respondents owning water-efficient equipment, by country (in %)

Country	Water efficient washing machine	Low volume or dual flush toilets	Water flow restrictor tap / low flow shower head	Water tank to collect rainwater
Australia	66	75	63	29
Canada	49	40	56	13
Czech Republic	28	67	67	34
France	62	61	43	27
Italy	58	42	58	12
Korea	31	31	40	11
Mexico	61	66	49	14
Netherlands	63	63	64	18
Norway	45	34	59	4
Sweden	44	40	48	13
OECD (10)	52	51	54	17

Table 3. Number of water-efficient equipments owned (in % of the country's sample)

Country	Number of water-efficient equipments					Total
	0	1	2	3	4	
Australia	9	15	27	34	16	100
Canada	25	24	27	19	6	100
Czech Republic	12	21	35	25	8	100
France	15	22	27	26	10	100
Italy	20	24	29	20	7	100
Korea	43	24	17	10	6	100
Mexico	15	21	29	27	7	100
Netherlands	12	18	29	33	8	100
Norway	24	30	29	15	2	100
Sweden	33	20	22	19	6	100
OECD (10)	21	22	27	23	8	100

Table 4. Type of equipment owned (in % of the country's sample of adopters)

Type of equipment	Canada	Netherlands	France	Mexico	Italy	Czech Republic	Sweden	Norway	Australia	Korea
Washing machine only	11	7	12	9	14	3	11	11	6	13
Low flush only	4	6	8	10	3	8	5	6	7	8
Flow restrictor only	15	6	3	4	11	10	12	22	3	20
Water tank only	1	1	3	2	1	3	1	0	1	1
Washing machine & low flush	6	10	15	18	7	4	8	5	11	6
Washing machine & flow restrictor	15	10	6	5	17	2	10	21	5	8
Washing machine & water tank	1	1	2	1	1	1	1	0	1	1
Low flush & flow restrictor	11	10	5	9	10	25	13	11	9	12
Low flush & water tank	0	1	3	1	0	4	1	0	2	1
Flow restrictor & water tank	2	1	1	1	1	4	1	1	1	2
Washing machine & low flush & flow restrictor	20	30	19	28	22	10	22	19	27	14
Washing machine & low flush & water tank	1	1	6	2	1	1	1	0	4	0
Washing machine & flow restrictor & water tank	3	2	2	1	2	1	4	0	2	1
Low flush & flow restrictor & water tank	2	3	4	2	1	15	2	0	4	1
All four equipments	8	9	11	8	8	9	8	3	17	11
Total	100	100	100	100	100	100	100	100	100	100

Table 5. Estimated coefficients from the four Probit models – pooled data

	Model 1 Water efficient washing machine		Model 2 Low volume or dual flush toilets		Model 3 Water flow restrictor tap / low flow shower head		Model 4 Water tank to collect rainwater	
Variable[(a)]	Coef.[(b)]	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Constant	-0.739	0.462	-0.577***	0.192	-2.228***	0.161	-2.302***	0.237
Economic variables								
i_owner	0.149***	0.033	0.240***	0.033	0.261***	0.033	0.404***	0.043
income	0.002**	0.001	0.002**	0.001	0.002**	0.001	-0.005***	0.001
Demographic variables								
hh_size	0.113**	0.044	0.022**	0.011	0.025**	0.011	0.049***	0.013
hh_size x hh_size	-0.009*	0.005	-	-	-	-	-	-
Characteristics of the dwelling								
size_resid (log)	-0.622***	0.215	0.041	0.030	0.009	0.029	-0.062*	0.035
$[\text{size\_resid (log)}]^2$	0.086***	0.026	-	-	-	-	-	-
size_outside (log)	0.014**	0.007	0.012*	0.007	0.015**	0.007	0.041***	0.013
$[\text{size\_outside (log)}]^2$	-	-	-	-	-	-	0.023***	0.003
age_resid (log)	-0.068***	0.017	-0.640***	0.083	-0.042**	0.017	-0.250**	0.099
$[\text{age\_resid (log)}]^2$	-	-	0.087***	0.015	-	-	0.054***	0.017
nb_rooms (log)	0.146***	0.037	0.146***	0.037	0.102***	0.037	0.006	0.046
Attitudinal and behavioural characteristics								
index_habit_water	0.180***	0.022	0.188***	0.022	0.316***	0.022	0.209***	0.028
index_env_concern	0.023	0.024	0.027	0.025	0.049**	0.024	0.037	0.030
i_time_orga	0.066	0.051	0.023	0.051	0.119**	0.051	0.193***	0.058
i_member_orga	0.099**	0.043	0.043	0.043	0.063	0.043	0.189***	0.049
index_green_prod	0.244***	0.025	0.211***	0.025	0.216***	0.025	0.152***	0.031
Policy variables								
i_nocharge (reference)	-	-	-	-	-	-	-	-
i_non-metered	0.135***	0.049	0.089*	0.049	0.084*	0.049	-0.073	0.067
i_metered	0.178***	0.041	0.248***	0.041	0.183***	0.041	-0.018	0.051
i_label	0.146***	0.035	0.087**	0.035	0.123***	0.035	0.019	0.042
Country dummies								
i_Australia (reference)	-	-	-	-	-	-	-	-
i_Canada	-0.275***	0.067	-0.787***	0.069	0.069	0.067	-0.361***	0.079
i_Czech Republic	-0.771***	0.076	-0.002	0.077	0.435***	0.076	0.316***	0.082
i_France	0.076	0.064	-0.293***	0.066	-0.389***	0.063	-0.010	0.070
i_Italy	-0.091	0.064	-0.842***	0.065	0.035	0.063	-0.441***	0.076
i_Korea	-0.649***	0.074	-1.060***	0.076	-0.231***	0.073	-0.237***	0.089
i_Mexico	-0.018	0.076	-0.229***	0.078	-0.216***	0.076	-0.463***	0.090
i_Netherlands	0.202***	0.066	-0.102	0.068	0.319***	0.066	-0.191**	0.075
i_Norway	-0.283***	0.071	-0.835***	0.074	0.304***	0.071	-0.909***	0.098
i_Sweden	-0.183***	0.069	-0.545***	0.070	0.023	0.068	-0.453***	0.082

Notes: (a) The prefix i_ indicates a 0/1variable. (b) *, **, *** indicate significance at the 10, 5, and 1% level, respectively.

Table 6. Estimated marginal effects from the four Probit models – pooled data

	Model 1 **Water efficient washing machine**	**Model 2** **Low volume or dual flush toilets**	**Model 3** **Water flow restrictor tap / low flow shower head**	**Model 4** **Water tank to collect rainwater**
Variable[(a)]	Marginal effect[(b)]	Marginal effect	Marginal effect	Marginal effect
Economic variables				
i_owner	0.059***	0.095***	0.103***	0.080***
income	0.001**	0.001**	0.001**	-0.001***
Demographic variables				
hh_size	0.045**	0.009**	0.010**	0.011***
hh_size x hh_size	-0.003*			
Characteristics of the dwelling				
size_resid (log)	-0.248***	0.017	0.004	-0.013*
$[\text{size\_resid (log)}]^2$	0.034***			
size_outside (log)	0.006**	0.005*	0.006**	0.009***
$[\text{size\_outside (log)}]^2$				0.005***
age_resid (log)	-0.027***	-0.255***	-0.017**	-0.053**
$[\text{age\_resid (log)}]^2$		0.035***		0.011***
nb_rooms (log)	0.058***	0.058***	0.040***	0.001
Attitudinal and behavioural characteristics				
index_habit_water	0.072***	0.075***	0.125***	0.044***
index_env_concern	0.009	0.011	0.019**	0.008
i_time_orga	0.026	0.009	0.047**	0.045***
i_member_orga	0.039**	0.017	0.025	0.043***
index_green_prod	0.097***	0.084***	0.086***	0.032***
Policy variables				
i_nocharge (reference)	-	-	-	-
i_non-metered	0.054***	0.035*	0.033*	-0.015
i_metered	0.071***	0.099***	0.072***	-0.004
i_label	0.058***	0.034**	0.049***	0.004
Country dummies				
i_Australia (reference)	-	-	-	-
i_Canada	-0.109***	-0.295***	0.027	-0.065***
i_Czech Republic	-0.289***	-0.001	0.164***	0.077***
i_France	0.030	-0.116***	-0.154***	-0.002
i_Italy	-0.036	-0.315***	0.014	-0.078***
i_Korea	-0.249***	-0.377***	-0.092***	-0.045***
i_Mexico	-0.007	-0.091***	-0.086***	-0.079***
i_Netherlands	0.080***	-0.040	0.123***	-0.037***
i_Norway	-0.112***	-0.311***	0.117***	-0.125***
i_Sweden	-0.073***	-0.211***	0.009	-0.078***

Notes: (a) The prefix _i indicates a 0/1variable. (b) *, **, *** indicate significance at the 10, 5, and 1% level, respectively.

Table 7. Diagnostic tests

	Model 1 Water efficient washing machine	Model 2 Low volume or dual flush toilets	Model 3 Water flow restrictor tap / low flow shower head	Model 4 Water tank to collect rainwater
Number of observations	9,439	9,439	9,439	9,437
LR chi^2(.)	1279.17	1571.82	1102.37	1348.08
Prob > chi^2	0.000	0.000	0.000	0.000
Percentage of correct predictions				
Overall	65.9%	66.6%	64.7%	84.0%
Sub-sample of adopters	72.8%	68.1%	74.9%	15.7%
Sub-sample of non-adopters	58.5%	64.9%	52.3%	97.9%
Variance Inflation Factor	9.94	4.03	1.82	4.07

Table 8. Estimated Costs and Benefits to the Household from Adopting Water-Efficient Equipment – An Example from Australia[(a)]

Type of equipment	Cost (without rebate)	Water Savings per year	Expected money savings per year[(b)]
Water-efficient washing machine	AUD 800	21,000 litres	AUD 14
Low flow shower head	AUD 50	15,000 litres	AUD 11
Dual flush toilet	AUD 150-200	35,000 litres	AUD 25

(a) Source: http://www.waterrating.gov.au/index.html

(b) Assuming a current water price of AUD 0.7 per m^3.

Appendix

A1. Selected questions from the survey

<u>Part on attitudinal and behavioural characteristics</u>:

Q22. How concerned are you about the following environmental issues?
Please select one answer per row

	Not concerned	Fairly concerned	Concerned	Very concerned	No opinion
Waste generation					
Air pollution					
Climate change (global warming)					
Water pollution					
Natural resource depletion (forest, water, energy)					
Genetically modified organisms (GMO)					
Endangered species and biodiversity					
Noise					

Q31. For each of the following categories, how often does your household choose to use the products listed, rather than the alternatives?
Please select one answer per row

	Never	Occasionally	Often	Always	Don't know
Paper with recycled content (e.g. stationery)					
Products with reduced toxic content (e.g. environmentally friendly cleaning products)					
Refillable containers (e.g. bottles, washing detergents)					
Reusable shopping bags					

<u>Part on water</u>:

Q87. Is your household charged for water consumption in your primary residence?

1. Yes
2. No
3. Not sure

IF Q87=1, ASK Q89

Q89. How is your household charged for water consumption?

1. Charged according to how much water is used (e.g. via a water meter)
2. Flat fee (e.g. lump sum included in charges or rent)
97. Don’t know

Q91. How often do you do the following in your daily life?
Please select one answer per row

	Never	Occasionally	Often	Always	Not applicable
Turn off the water while brushing teeth					
Take showers instead of bath specifically to save water					
Plug the sink when washing the dishes					
Water your garden in the coolest part of the day to reduce evaporation and save water					
Collect rainwater (e.g in water tanks) or recycle waste water					

Q92. Has your household invested in the following appliances/devices in the past 10 years in your current primary residence? If these measures would need to be carried out by the landlord, select "Not possible".

	Yes	No	Already equipped	Not possible (code 96)
Water efficient washing machines				
Low volume or dual flush toilets				
Water flow restrictor taps / low flow shower head				
Water tank to collect rainwater				
Water purifier for drinking water				

A2. Construction of the behavioural and attitudinal indices

a) Index measuring households' habits to conserve water (variable name: *index_habit_water*)

This index is built from the respondents' answers to question Q91 (see Appendix A1). For each household, we compute the index as the sample mean on the answers coded from 1 to 4. We do not consider in the computation the case of answers equal to 5. For example, a household living without any garden or balcony cannot answer the question "How often do you water your garden in the coolest part of the day to reduce evaporation and save water"? For example, a household who respectively answered "never", "occasionally", "often", "always", and "always" to the five questions would be attributed an index of (1 + 2 + 3 + 4 + 4)/5 = 2.8.

Note however that we consider a slightly different definition of this index in the model describing the probability that households own a water tank to collect water. We exclude the answer to the 5th question in Q91 in the survey (which is directly about rainwater collection) in order to avoid endogeneity bias at the estimation stage.

b) Index measuring households' habit to purchase "green" products (variable name: *index_green_prod*)

This index is constructed in a similar manner based on Q31.

c) Index measuring households' concern about environmental problems (variable name: *index_env_concern*)

This index is constructed in a similar manner based on Q22.

A3. List and definition of the explanatory factors

Below is the list of the explanatory variables that have been used in this article. Variable names with prefix "i_" indicate variables taking only values 0 or 1. Variable names with prefix "index_" indicate indices representing respondents' attitudinal characteristics (see notes at the end of Table A1 and Appendix A2).

Table A1. List of explanatory factors used in the various models

Variable names	Variable definitions
Characteristics of the dwelling	
nb_rooms[(a)]	Number of rooms
size_resid[(b)]	Size of primary residence
size_outside[(b)]	Size of garden/balcony/terrace
age_resid	Age of primary residence
Economic variables	
i_owner	Equal to 1 if the household owns its residence
income	Household's income (1,000 EUR)
Demographic variables	
age	Age of the respondent
i_female	Equal to 1 if the respondent is a female
hh_size[(c)]	Household size
i_pgrad	Equal to 1 if the respondent holds a post graduate degree
Behavioural and attitudinal characteristics	
index_env_concern[(d)]	Index of concern about environmental issues
index_habit_water[(d)]	Index measuring the respondent's habits to conserve water
index_green_prod[(d)]	Index of purchase of "green products"
i_time_orga	Equal to 1 if the respondent has invested some personal time to support or participate in an environmental organisation
i_member_orga	Equal to 1 if the respondent is currently a member of, or contributor/donator to, any environmental organisations
Policy variables	
i_nocharge	Equal to 1 if not charged for water
i_non-metered	Equal to 1 if charged for water but non-metered
i_metered	Equal to 1 if charged for water and metered
i_label[(e)]	Equal to 1 if the household takes labels into account in purchasing decisions

Notes:

(a) In the survey, "number of rooms" was a categorical variable with the last category defined as "twelve and more rooms". We decided to transform this discrete variable into a continuous variable and we considered a number of 12 rooms for households who chose the highest category.

(b) There were some missing observations for the answer on the size of the residence and the size of the property outside the residence. In order to avoid losing observations, we replaced the missing data by the average size of the residence and the average size outside the residence in the corresponding country and zone of residence (urban, peri-urban, rural).

(c) In the survey, "household size" was a categorical variable with the last category defined as "five and more members". We decided to transform this discrete variable into a continuous variable and we considered a number of 5 members for households who chose the highest category.

(d) See Appendix A2 for details on the computation of indices.

(e) We consider any "environmental label", including applicable national eco-labels, Nordic eco-labels, the European Union eco-label and water-specific labels.

Table A2. Sample mean of socio-economic, demographic, attitudinal and policy variables, overall and by country

Variable	OECD (10)	Australia	Canada	Czech Rep	France	Italy	Korea	Mexico	Netherlands	Norway	Sweden
i_owner	0.65	0.58	0.63	0.66	0.58	0.80	0.72	0.74	0.48	0.78	0.49
nb_rooms	4.88	6.02	6.24	4.00	4.75	5.27	3.46	5.31	4.20	5.30	3.85
size_resid (m^2)	101.18	93.33	115.03	89.74	95.54	109.71	91.61	106.30	88.97	120.68	94.14
size_outside (m^2)	77.58	120.35	61.22	83.35	122.29	57.30	21.41	37.27	67.60	120.92	90.35
age_resid	31.85	27.53	34.24	40.59	39.57	32.13	12.29	18.67	37.44	35.65	42.19
income (1,000 EUR)[a]	30.258	34.981	38.548	11.710	32.349	30.735	24.912	6.782	28.467	58.627	28.743
age	42.15	43.90	43.21	39.51	45.74	43.52	38.61	34.77	45.05	43.52	42.07
i_female	0.52	0.55	0.51	0.51	0.50	0.52	0.51	0.49	0.53	0.48	0.56
hh_size	2.89	2.87	2.63	3.02	2.57	3.12	3.70	3.81	2.30	2.56	2.31
i_pgrad	0.10	0.07	0.06	0.10	0.13	0.07	0.09	0.12	0.05	0.26	0.03
index_env_concern	3.03	3.06	3.05	2.95	3.04	3.18	3.30	3.54	2.59	2.76	2.74
index_habit_water	2.99	3.41	3.00	2.92	3.25	3.03	2.56	3.02	3.17	2.55	2.91
index_green_prod	2.86	3.03	2.99	2.87	2.97	2.93	2.71	3.00	2.78	2.59	2.74
i_time_orga	0.10	0.07	0.07	0.07	0.05	0.11	0.08	0.27	0.04	0.06	0.15
i_member_orga	0.14	0.15	0.11	0.08	0.09	0.13	0.18	0.15	0.25	0.08	0.17
i_nocharge	0.24	0.22	0.52	0.10	0.13	0.08	0.10	0.03	0.08	0.49	0.67
i_non-metered	0.13	0.04	0.13	0.10	0.10	0.13	0.04	0.23	0.11	0.35	0.08
i_metered	0.63	0.73	0.35	0.80	0.77	0.79	0.86	0.75	0.81	0.16	0.25
i_label	0.37	0.67	0.25	0.49	0.24	0.09	0.18	0.00	0.29	0.70	0.91

(a) Computed using International Monetary Fund nominal exchange rates 16/01/08.